

APPENDIX J
Revised Mitigation Plan

**Miami Harbor GRR Study
Environmental Impact Statement
Revised Mitigation Plan**

January 2004

**Prepared for:
U.S. Army Corps of Engineers
Jacksonville District
701 San Marco Blvd
Jacksonville, FL 32207**

**Prepared by:
Dial Cordy and Associates Inc.
490 Osceola Avenue
Jacksonville Beach, FL 32250**

EXECUTIVE SUMMARY

This report outlines compensatory mitigation for unavoidable impacts to seagrass and offshore hardbottom/reef habitats impacted by implementation of the Recommended Plan (Alternative 2). Direct impacts include 7.9 acres of seagrass habitat, 49.4 acres (3.3 acres new impacts) of hardbottom/reef habitat outside or deeper than the present authorized channel width and depth, 123.5 acres of rock/rubble habitat previously impacted by channel dredging, and 236.4 acres of unvegetated sand/silt bottom located in the authorized channel. Of these impacts, mitigation is proposed for seagrass and hardbottom/reef habitats where new construction or dredging is proposed. The South Atlantic Fishery Management Council (SAFMC) and National Marine Fisheries Service (NMFS) consider seagrass and reef habitat types Essential Fish Habitat (EFH) (SAFMC 1998). For dredging the rock/rubble and unvegetated bottom within the channel, mitigation is not proposed since dredging was previously performed in the channel and temporal impacts are minimal.

Seagrass Impacts and Mitigation

Direct impacts to seagrass communities are restricted to the widening of Fisherman's Channel cut and the Fisher Island Turning Basin. Impacts include the permanent loss (removal) of 0.2 acre of mixed seagrass beds. Indirect losses will occur from the natural equilibration of the side slopes described in Appendix G of the EIS, resulting in the loss of 7.7 acres of seagrass. Based upon coordination with the resource agencies and comments received on the DEIS, restoration of approximately 24 acres of seagrass beds is proposed as compensation for unavoidable impacts.

In order to replace local seagrass functions and values, restoration will be implemented within Biscayne Bay, preferably in areas where seagrass once occurred and is now absent due to past anthropogenic activities such as dredging. Seagrass habitat will be restored by filling approximately 24 acres of old borrow areas located in North Biscayne Bay. Based on a 1989 report prepared by DERM, there are eight borrow areas which were considered suitable for filling with dredged material, capping with sand, and restoring seagrass habitat to an elevation consistent with the depths where adjacent seagrass beds are present (CTC 1989). Further site evaluations of the area were conducted in June 2002, July 2003, and October 2003 to determine the most appropriate site for seagrass mitigation. The mitigation plan presented in the DEIS has been revised based on the results of the subsequent surveys of the proposed mitigation site.

The preferred mitigation area is a series of interconnected submerged borrow holes located just north of Julia Tuttle Causeway (Interstate 195) where seagrass habitat has been removed in years past by dredging fill for the causeway construction.

Dredged material will either be hauled or pumped to the selected borrow area(s) based on engineering analysis, cost, and recipient site conditions. Dredged material will be placed into

the borrow areas. It is assumed that this can be accomplished without a coffer dam and will require a variance from water quality standards within a defined mixing zone. It is anticipated that ambient depths will range from -4 feet to -7 feet MSL in the restored areas following restoration and that seagrass recruitment will occur rapidly. Beds of *H. decipiens*, *H. wrightii*, and *S. filiforme* have been documented adjacent to the proposed mitigation site and are expected to serve as recruitment sources. Site monitoring will be conducted for five years to document the characteristics and extent of recruitment. Detailed plans and specifications for the seagrass restoration will be prepared and provided for agency concurrence prior to construction.

Hardbottom Impacts and Mitigation

New impacts to low relief hardbottom and high relief hardbottom total 0.6 acre and 2.7 acres, respectively. Based on the Habitat Equivalency Analyses calculations (Appendix A), direct impacts to reef and hardbottom habitats would require the creation of artificial reef habitat at an effective mitigation ratio of 2.0 for high relief hardbottom/reef habitat and an effective mitigation ratio of 1.3 for low relief hardbottom/reef habitat. Mitigation reefs will be constructed in two different designs, to reflect the differences in the habitat structure of the two types of reef/hardbottom habitat to be impacted. The proposed mitigation will be type-for-type, to reflect the ecological differences between the different reef types impacted. A total of 0.8 acre of low relief-low complexity (LRLC) reef will be required to mitigate for the new low relief hardbottom/reef and previously impacted hardbottom habitat. A total of 5.4 acres of high relief-high complexity (HRHC) reef would be required to mitigate for the high relief impact. Reefs will be constructed at proposed artificial reef sites to be managed by DERM.

Native rock excavated from the Entrance Channel will be used in reef construction. Artificial reef construction will be conducted at one or two of the sites located south of the entrance channel identified in Appendix L of the EIS. The dredged rock material will be deployed to mimic the orientation of typical natural reefs. This reef design will have an approximate vertical relief of 3 to 5 feet to provide the maximum structural complexity and to provide refugia for cryptic and reclusive species. As interstitial sand patches associated with reef habitat are thought to be important in the ecological function of the reef habitat, the reef footprint will contain approximately 20 percent open sand surface. Temporary buoys delineating the deployment strip will mark areas for deployment. Corner buoys for the sites shall be placed using DGPS with sub-meter accuracy. Natural excavated rock from the dredged channel will provide an ideal substrate for the establishment of a fouling community and colonization by the common reef community species. HRHC reefs are intended to provide persistent habitat with higher complexity and habitat diversity than LRLC hardbottom or reefs.

LRLC reefs will have a vertical relief of 1 to 2 feet and will be placed inshore of, and shallower than, HRHC reefs. It is recognized that the LRLC reefs may be periodically buried by shifting sands, like the low relief natural reefs they are intended to mimic. This does limit their habitat value to some extent, but it has been suggested (albeit without much empirical

evidence) that this sort of ephemeral, low relief habitat may be particularly important in supporting the recruitment and post settlement survival of juvenile fishes. Natural rock excavated from the channel as described above and placed in sites where they may be expected to partially settle in the substrate, should provide LRLC habitat. Deployment sites will be delineated as outlined above for HRHC reefs.

The monitoring program for the mitigation reefs will consist of both physical and biological components. Physical monitoring one year after placement will assess the degree of settling of the reef materials, and biological monitoring will assess populations of algae, invertebrates, and fishes, as compared with concurrent control sampling of natural reefs. Biological monitoring will be conducted annually in the summer months for five years. Each monitoring effort will include video transects of the mitigation reefs to document Snapper Grouper Complex utilization.

TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	II
LIST OF FIGURES	VI
LIST OF TABLES	VI
1.0 INTRODUCTION.....	1
1.1 Mitigation Policies	1
2.0 MITIGATION OPTIONS	5
3.0 MITIGATION REQUIREMENTS	9
3.1 Seagrass	9
3.2 Hardbottom/Reef	12
4.0 PROPOSED PLAN	14
4.1 Seagrass Restoration.....	14
4.1.1 Conceptual Seagrass Site Design	17
4.2 Artificial Reef Creation	21
4.2.1 General Design Requirements	21
4.2.2 Reef Design	24
4.2.3 Reef Monitoring	25
5.0 EFFECTIVENESS OF PROPOSED MITIGATION.....	27
5.1 Seagrass Restoration.....	27
5.2 Artificial Reef Construction	28
6.0 REFERENCES	29

APPENDICES

Appendix A	Habitat Equivalency Analysis
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LIST OF FIGURES

	Page
Figure 1 Locations of Potential Mitigation Options.....	6
Figure 2 Natural Resource Impacts	10
Figure 3 Proposed Seagrass Mitigation Site.....	16
Figure 4 Seagrass Mitigation Conceptual Design	20
Figure 5 Location of Offshore Artificial Reef Sites	22
Figure 6 Artificial Reef Design for Low and High Relief Reef.....	23

LIST OF TABLES

	Page
Table 1 Summary of Mitigation Project Sites	7
Table 2 Dredging Impacts by Habitat Type	11
Table 3 Reef and Hardbottom Impacts and Proposed Artificial Reef Ratios and Areas	13

1.0 INTRODUCTION

This report outlines compensatory mitigation for unavoidable impacts to seagrass and offshore hardbottom/reef habitats impacted by implementation of the Recommended Plan considered in the Draft Environmental Impact Statement (DEIS). Direct impacts to the total project include 7.9 acres of seagrass habitat, 49.4 acres of reef habitat outside or deeper than the present authorized channel width and depth, 123.5 acres of rock/rubble habitat previously impacted by channel dredging, and 236.4 acres of unvegetated sand/silt bottom located in the authorized channel. Of these impacts, mitigation will be required for seagrass and hardbottom/reef habitats where new construction or dredging is proposed. The South Atlantic Fishery Management Council (SAFMC) and National Marine Fisheries Service (NMFS) (SAFMC 1998) consider all of these habitat types Essential Fish Habitat (EFH). For dredging the rock/rubble and silt/sand/rubble bottom within the channel, mitigation is not proposed since dredging was previously performed in the channel and temporal impacts are minimal.

1.1 Mitigation Policies

A summary of mitigation programs and policies in effect by the Corps and Federal reviewing agencies, including the Environmental Protection Agency (EPA), U.S. Fish and Wildlife Service (FWS), and NMFS, are provided below.

U.S. Army Corps of Engineers Mitigation Policy

Damages to fish and wildlife resources will be prevented to the extent practicable through good planning and design incorporating the mitigation principles defined within the Council on Environmental Quality's (CEQ) NEPA guidelines, i.e., first avoid the impact; next, minimize the impact; and, finally compensate for unavoidable damages to significant fish and wildlife resources. Measures to offset unavoidable damages to significant fish and wildlife resources will be included in projects when the cost of these measures are justified by the combined monetary and non-monetary benefits attributable to the proposed measures. These mitigation plans are to contain the most efficient and least costly measures appropriate to reduce fish and wildlife resource losses. Mitigation of losses will be provided to the maximum extent practicable through the development and implementation of mitigation measures on project lands. If project lands cannot fulfill our mitigation requirements, then separable public lands adjacent to project lands, to the extent possible, should be considered next. Any consideration of separable private lands not adjacent to project lands should be the last option considered. Acquisition of an interest in any lands or waters for mitigation of damages to fish and wildlife resources that do not comply with the limited authority provided by Subsection 906(b) of WRDA 1986 requires specific congressional authorization (See paragraph 19-8.a(2)). Measures to mitigate project caused damages to significant fish and wildlife resources are project costs and will be allocated to the responsible (causative) purposes of the project in the same way as other project costs. Mitigation costs will also be

shared to the same extent as the other costs allocated to such purposes are shared. The mitigation costs include separable first costs (any lands and construction) and separable operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) costs (EP 1165-2-1; 30 Jul 99).

U.S. Environmental Protection Agency Mitigation Policy

Policy regarding mitigation under the Clean Water Act (CWA) Section 404(b)(1) guidelines were expressed within a Memorandum of Agreement (MOA) between EPA and the U.S. Army Corps of Engineers (USACE) and became effective February 7, 1990. The purpose of the MOA is to provide guidance to determine appropriate and practicable mitigation under the Section 404 Regulatory Program. Practicable is defined as “available and capable of being done after taking into consideration cost, existing technology, and logistics in light of the overall project purposes.”

According to the MOA, on-site mitigation is preferable to off-site mitigation. Similarly, in-kind mitigation is preferable to out-of-kind mitigation. However, EPA may prefer off-site or out-of-kind mitigation if it is the most practicable solution. EPA expressed a preference of restoration of wetlands over creation of wetlands from upland habitat for two reasons. First, EPA considers the likelihood of success higher for restored wetlands than for created wetlands. Second, EPA is concerned about the reduction of potentially valuable uplands resulting from the mitigation.

The MOA states that the objective of mitigation for unavoidable impacts is to offset environmental losses. Mitigation should provide, at a minimum, one for one functional replacement (i.e., no net loss of wetland value), with an adequate margin of safety to reflect the expected degree of success, but this requirement may not be appropriate and practicable in all cases. A minimum of 1:1 acreage replacement may be used as a reasonable surrogate for no net loss of functions and values where definitive information is lacking. However, this ratio may be greater where the wetland being impacted is high and the replacement wetlands are of lower functional value or the likelihood of success is low. Conversely, the ratio may be less than 1:1 for areas where the wetland being impacted is low and the likelihood of success associated with the mitigation proposed is high.

U.S. Fish and Wildlife Service Mitigation Policy

The U.S. Fish and Wildlife Service Mitigation Policy (January 23, 1981) established policy for mitigating the adverse impacts of land and water developments on fish, wildlife, and their habitats. According to the policy, compensation may be accepted for wetland impacts in a variety of ways. Mitigation activities may include: wildlife management activities, habitat construction activities, fishery propagation, protective designations on public lands, buffer zones, property leases, wildlife easements, water right acquisition, and fee title acquisition. Compensatory mitigation actions should only occur after all efforts to avoid and minimize impacts have been utilized. FWS policy states that appropriate mitigation for unavoidable wetland impacts are based on the resource value of the potential impacted wetland. Four

categories of resource value have been defined by the FWS for which different levels of mitigation may be determined.

A wetland classified as Resource Category 1 consists of high value wetland that is unique and irreplaceable on a national basis or in the eco-region. For this category, no loss of existing habitat value is the goal, and the FWS will recommend that all losses of existing habitat be prevented.

A Resource Category 2 wetland is of high value and relatively scarce on a national basis or within the eco-region. For this category, the FWS maintains a goal of no net loss of in-kind value. If unavoidable loss is likely to occur, in-kind replacement will be the recommendation. An exception to this rule may occur where the out-of-kind replacement is of greater value than the habitat to be impacted, or in-kind replacement is not physically or biologically obtainable in the region.

A Resource Category 3 wetland is of high to medium value and is relatively abundant on a national basis. The FWS mitigation goal is no net loss of habitat value while minimizing loss of in-kind habitat value. For impacts to Resource Category 3 wetlands, in-kind replacement is preferred. If in-kind replacement is not practicable, out-of-kind creation or restoration, or increased management of replacement habitat that increases the value of the existing habitat can achieve mitigation goals.

A Resource Category 4 wetland is of medium to low value, with a goal of minimum loss of habitat value. Compensatory mitigation for unavoidable losses to Resource Category 4 wetlands may be required.

National Marine Fisheries Service

As described in the Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), the EFH provisions of the act support one of the nation's overall marine resource management goals – maintaining sustainable fisheries.

The focus of the mitigation policy is to conserve and enhance EFH and to avoid, minimize, or compensate for impacts to EFH due to development activities. As with the other federal agency policies, the primary goal of any action is to avoid impacts to natural resources. However, if impacts to these resources are unavoidable, compensatory mitigation may be required. When unavoidable impacts to EFH occur, the NMFS will recommend mitigation measures to compensate for any loss of resource value. Recommendations may include: restoration of riparian and shallow coastal areas (i.e., re-establishment of vegetation, restoration of hardbottom characteristics, removal of unsuitable material, and replacement of suitable substrate), upland habitat restoration, water quality improvement or protection, watershed planning, and habitat creation. The preferred type of mitigation is enhancement of existing habitat, followed by restoration, and finally creation of new habitat.

Mitigation should focus on the replacement of lost habitat and associated values attributed to the habitat and toward maintaining sustainable fisheries. In particular, mitigation should be targeted toward impacts as a result of the proposed action to the listed managed species discussed in the Environmental Impact Statement (EIS).

Mitigation for EFH should focus on the replacement of lost habitat and associated values attributed to the habitat and towards maintaining sustainable fisheries. Since no definitive policy is currently available on mitigating EFH impacts, development of mitigation strategies is subjective and somewhat difficult to address. Therefore, mitigation for EFH impacts must focus on strategies that enhance fisheries production and help ensure the sustainability of fisheries. Creation of mangrove habitat and mud flats, enhancement of fisheries resources by creating shallow water habitat or artificial structures, restoration of seagrass habitat where feasible, and preservation of environmentally sensitive waterfront land threatened by development are all viable options that can compensate for impacts to EFH, and have been used and accepted elsewhere.

Mitigation requirements for EFH impacts, associated with proposed dredging of channels and basins, are difficult to define. While these areas will see a temporary loss of benthic production, all the affected areas will see recruitment of the benthic community, followed by fish utilization of the habitat. All of these dredged areas will continue to provide food chain support and act as functional EFH habitat, including the turning basins, terminals and inner and outer Entrance Channels. Since the existing harbor basin provides seasonal fishery habitat, we would expect the proposed basin to likewise provide comparable habitat.

2.0 MITIGATION OPTIONS

A total of 25 mitigation options have been identified that could serve as full or partial mitigation for impacts to seagrasses in Biscayne Bay (Figure 1). The amount of site-specific information known at this time varies among projects listed below. Table 1 summarizes the mitigation potential of each site identified to date. Options explored vary from significant restoration of mangrove communities in Biscayne Bay; restoring prop scars adjacent to Virginia Key and restoring seagrass habitat in North Biscayne Bay through filling of old borrow areas with dredged material.

Based on significant coordination with Federal, state, and local resource agencies in-kind restoration of seagrass habitat is the agency-preferred option for mitigating seagrass impacts. In the event that restoration of seagrass habitat is not feasible or no sites acceptable to the resource agencies are available, other options will be explored. Restoration of seagrass habitat through filling of old borrow areas in North Biscayne Bay is the preferred choice and is further discussed and analyzed in Sections 3 and 4 of this plan.

In a survey completed in October 2002, the Corps mapped a former borrow location located in northern Biscayne Bay for the purpose of using this site for seagrass mitigation. For a detailed review of the recommended site for seagrass restoration, reference Appendix L of the EIS.



Source: Patricia L. McNeese; The Curtis & Kimball Company; Case O'Bourke Engineering




Location of Potential Mitigation Options	
Revised Mitigation Plan	
Miami Harbor General Reevaluation Report	
Final Environmental Impact Statement	
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	Figure 1

Table 1 Summary of Mitigation Project Sites

PROJECT NAME	OWNER	PROJECT DESCRIPTION			BENEFITS			
		Habitat	Credit Type	Acres	Wild-life	T/E Species	Water Quality	Public Park
Chapman/Matheson	Dade County							
Old King's Bay Landfill		Tidal mangroves	Restoration	10.23	X	X	X	
Small Fill Pad		Tidal mangroves	Restoration	1.63	X	X	X	
Old Plant Nursery		Brackish marsh	Creation	8.55	X	X	X	X
		Tidal mangroves, brackish marsh	Enhancement					
			Total:	13.04				
East Culvert		Tidal mangroves and lagoon	Enhancement	48	X	X	X	
Middle Culvert		Tidal mangroves and lagoon	Enhancement	48	X	X	X	
West Culvert and Spoil		Tidal mangroves, brackish marsh	Enhancement	55	X	X	X	
Exotics Eradication		Tidal mangroves, brackish marsh	Enhancement	40.83	X	X	X	X
Main Fill Pad		Tidal mangroves	Restoration	unk	X	X	X	X
			Enhancement	unk				
			Total:	19.4				
Old South Dade Landfill	Dade County	Brackish marsh	Restoration	20	X		X	
Virginia Key								
Marine Stadium	Dade County, City of Miami	Seagrass	Restoration	4.62	X	X	X	
		Tidal mangroves	Creation	9.47				
		Tidal mangroves	Restoration	1.32				
		Brackish marsh	Creation	4.14				
			Total:	19.55				

Table 1. (continued).

PROJECT NAME	OWNER	PROJECT DESCRIPTION			BENEFITS			
		<i>Habitat</i>	Credit Type	Acres	Wild-Life	T/E Species	Water Quality	Public Park
Virginia Key								
Virginia Key Impounded	Dade County	Forested freshwater wetlands	Enhancement and Creation	48.13	X		X	
Sewage Treatment East		Tidal mangroves	Restoration	0.77	X		X	
		Tidal mangroves	Enhancement	4.4				
		Coastal upland buffer	Creation	1.74				
			Total:	6.91				
Sewage Treatment West	Dade County	Tidal mangroves	Restoration	7	X		X	
Spoil Islands	Dade County	Coastal hammock, Tidal mangroves	Creation	unk	X		X	
Virginia Beach Hammock	City of Miami	Coastal hammock	Restoration	unk	X		X	X
CWA/BAP Seagrass	State of Fla.	Seagrass	Restoration	unk	X	X	X	
BNP Seagrass	USA	Seagrass	Restoration	unk	X	X	X	X
EEL Program	Private		Preservation					
Biscayne Wetlands		Coastal wetlands		445	X	X	X	
Black Point Wetlands		Coastal wetlands		192	X	X	X	
Cutler Wetlands		Coastal wetlands		1,194	X	X	X	
Hardy Matheson Addition		Coastal wetlands		42	X	X	X	
Deering Estate N. Addition		Coastal wetlands		5	X	X	X	
Vizcaya Hammock Addition		Coastal uplands		2	X			
Oleta River State Park	State of Fla.	Mangrove wetlands	Restoration	7	X		X	X
North Biscayne Bay Borrow Areas	State of Fla.	Seagrass	Restoration	±40 *	X	X	X	

* Potentially available for restoration

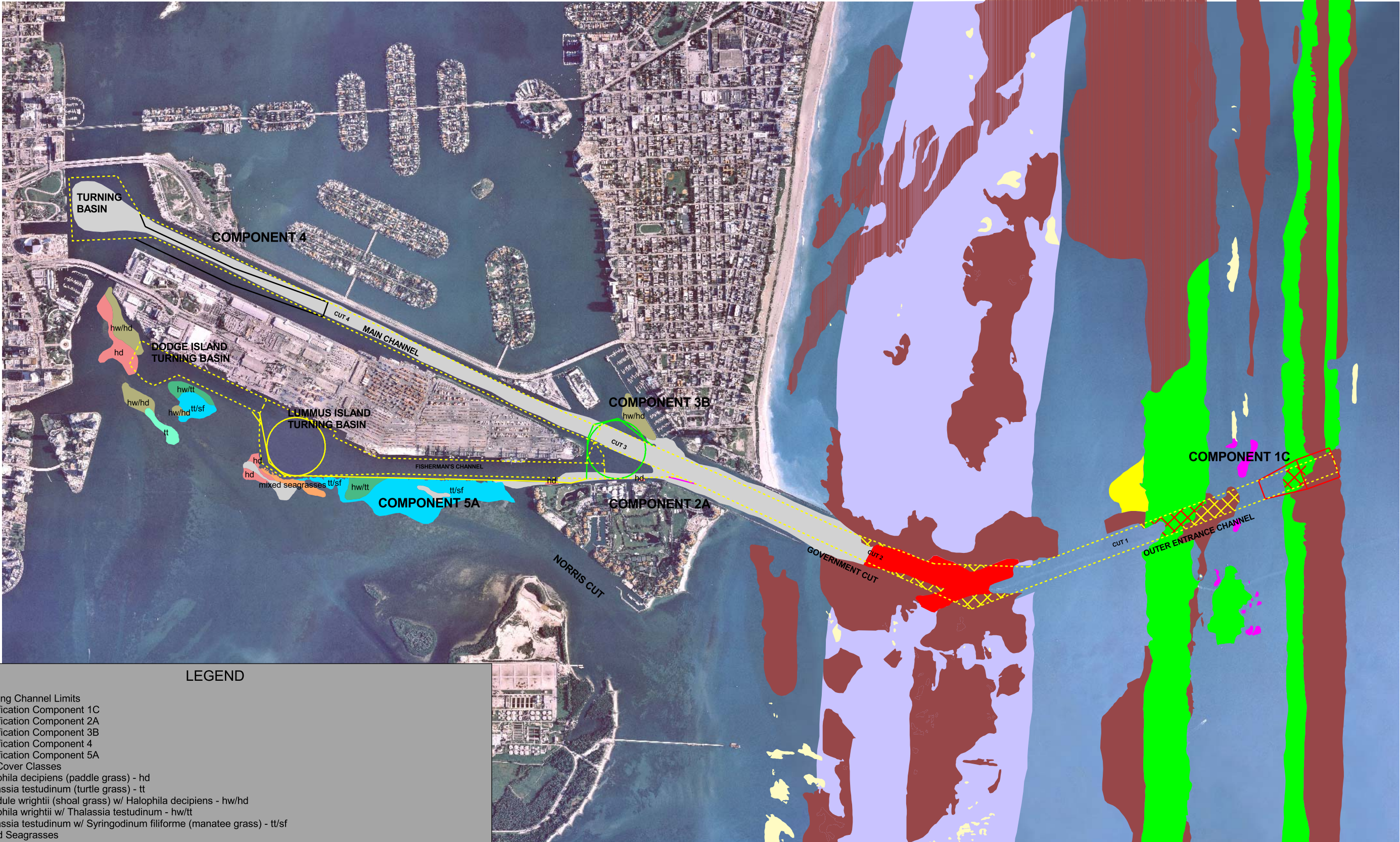
3.0 MITIGATION REQUIREMENTS

3.1 Seagrass

Direct impacts to seagrass communities are restricted to the widening of Fisherman's Channel cut and the Fisher Island Turning Basin. Impacts include the permanent loss (removal) of 0.2 acre of mixed seagrass beds. Indirect losses will occur from the natural equilibration of the side slopes as described in Appendix G of the EIS, resulting in the loss of 7.7 acres of seagrass. Based upon coordination with the resource agencies and comments received on the DEIS, restoration of approximately 24 acres of seagrass beds is proposed as compensation for unavoidable impacts.

In order to replace local seagrass functions and values, restoration will be implemented within Biscayne Bay, preferably in areas where seagrass once occurred and is now absent due to past anthropogenic activities such as dredging. Seagrass habitat will be restored by filling at least 24 acres of old borrow areas located in North Biscayne Bay. Based on a 1989 report prepared by DERM, there are eight borrow areas which were considered suitable for filling with dredged material, capping with sand, and restoring seagrass habitat to an elevation consistent with the depths where adjacent seagrass beds are present (CTC 1989). Further site evaluations of the area were conducted in June 2002, July 2003, and October 2003 to determine the most appropriate site for seagrass mitigation. The mitigation plan has been revised based on the results of the subsequent surveys of the proposed mitigation site.

Restoration of seagrass communities, while still considered experimental by some resource agencies, can enhance habitat heterogeneity and the diversity of invertebrate and fish communities, if carefully implemented. The recent treatise on seagrass restoration entitled "Guidelines for the Conservation and Restoration of Seagrasses in the United States and Adjacent Waters" by Fonseca et al. (1998) discusses the benefits, risks, and successful approaches associated with seagrass restoration. Given the documented success of more recent efforts to restore seagrass communities including those in South Florida, restoration is quickly becoming a proven resource management tool in some areas where conditions are appropriate.



LEGEND

- Existing Channel Limits
- Modification Component 1C
- Modification Component 2A
- Modification Component 3B
- Modification Component 4
- Modification Component 5A
- Seagrass Cover Classes
 - Halophila decipiens (paddle grass) - hd
 - Thalassia testudinum (turtle grass) - tt
 - Halodule wrightii (shoal grass) w/ Halophila decipiens - hw/hd
 - Halophila wrightii w/ Thalassia testudinum - hw/tt
 - Thalassia testudinum w/ Syringodium filiforme (manatee grass) - tt/sf
 - Mixed Seagrasses
- Hardbottom and Reef Cover Classes
 - Scattered Rock/Rubble w/ Algae-Sponge Communities
 - Scattered Rock/Rubble w/ Live Bottom Assemblage
 - Patchy Low Relief - Low Density of Gorgonian Coverage in Sand
 - Patchy High Relief - Moderate Density of Gorgonian and Sponge Coverage in Sand
 - Low Relief - Low/Moderate Density of Gorgonian Coverage w/ Scattered Patches of Sand
 - High Relief - Moderate/High Density of Gorgonian and Sponge Coverage
 - Low Relief (Previously Dredged) - Low/Moderate Density of Gorgonian Coverage w/ Scattered Patches of Sand
 - High Relief (Previously Dredged) - Moderate/High Density of Gorgonian and Sponge Coverage
- Underlying Substrate
 - Oolitic Limestone Bedrock w/ Variable Sand Veneer Coverage




Natural Resource Impacts	
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Miami Harbor General Reevaluation Report	
Final Environmental Impact Statement	
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Figure 2	

Table 2 Dredging Impacts by Habitat Type

Habitat Type and Current Dredge Status	Component					Total
	1C	2A	3B	4	5A	
Seagrass- new impacts, side slope equilibration to areas not previously dredged that exist <i>outside proposed channel boundaries</i> (ac)	0.0	0.0	0.1	0.0	7.6	7.7
Seagrass- new impacts, not previously dredged, inside proposed channel boundaries (ac)	0.0	0.0	0.0	0.0	0.2	0.2
Low relief hardbottom/reef- new impacts, not previously dredged (ac)	0.6	0.0	0.0	0.0	0.0	0.6
Low relief hardbottom/reef, previously dredged and recolonized (ac)	28.1	0.0	0.0	0.0	0.0	28.1
High relief hardbottom/reef- new impacts, not previously dredged (ac)	2.7	0.0	0.0	0.0	0.0	2.7
High relief hardbottom/reef, previously dredged and recolonized (ac)	18.0	0.0	0.0	0.0	0.0	18.0
Rock/rubble w/ live bottom- new impacts, not previously dredged (ac)	0.00	0.0	0.0	0.0	0.0	0.0
Rock/rubble w/ live bottom, previously dredged and recolonized (ac)	51.7	0.0	0.0	0.0	0.0	51.7
Rock/rubble w/ algae/sponges- new impacts, not previously dredged (ac)	0.0	0.6	0.9	0.0	1.5	3.0
Rock/rubble w/ algae/sponges, previously dredged and recolonized (ac)	41.3	0.0	25.2	0.0	2.3	68.8
Unvegetated (i.e., sand/silt/rubble, sand habitats without seagrasses)- new impacts, not previously dredged (ac)	1.3	0.0	5.3	0.0	16.7	23.3
Unvegetated (i.e., sand/silt/rubble, sand habitats without seagrasses), previously dredged (ac)	66.9	0.0	19.1	0.0	127.1	213.1
Project Footprint, excludes seagrass impacts that are outside proposed channel boundaries and “deepwater non-impacts” (ac)	210.6	0.6	50.6	0.0	153.8	441.5

*Channel Wall Impacts are not included in the table.

3.2 Hardbottom/Reef

Mitigation Requirements

To calculate the acreage of creation of artificial reef required for compensation, Dial Cordy and Associates Inc. performed Habitat Equivalency Analyses (HEA) (see NOAA 2000). The method used was designed to take into account both projected impact acreages for various habitats and recovery times to calculate the overall loss of habitat function that occurs from the time a new impact occurs to the time of full functional recovery. HEA is usually applied to situations where previously non-impacted habitats are damaged and was used, in this case, to calculate compensatory mitigation acreages for removal of habitat in previously undredged areas. Projected impact acreages were not only classified according to the method that would be applied to calculate functional loss, but were further classified according to relief/profile. This was necessary because the proposed mitigation will be type-for-type, to reflect the ecological differences between the hardbottom/reef types impacted.

Several assumptions are involved in the HEA method. These assumptions include (1) the relative functionality (usually expressed as a percentage) of both impact and mitigation areas at “time-0” (time zero) (i.e., at the initiation of mitigation operations or at the time the impact occurs to the habitat), (2) the relative functionality of both the impact and mitigation area at the completion of recovery of each area, (2) the form of the recovery function (e.g., linear, exponential, hyperbolic, etc.), and (3) the recovery/completion time for the impact area and mitigation area to reach full functionality (i.e., the level that existed prior to impact/mitigation activities). For low relief hardbottom/reefs assessed with HEA, the following assumptions were used: (1) dredging would leave habitat 10 percent functional, (2) habitat value in both the impact and mitigation areas would increase in a linear fashion, (3) both the impact and mitigation areas will reach full (i.e., 100%) functionality in 12 years, and (2) placement of substrate in the mitigation area will immediately result in 20 percent of full habitat function. For high-relief hardbottoms assessed with HEA, the same assumptions were used, except recovery to full functionality was based on a 30-year period.

Based on the HEA calculations, direct impacts to reef and hardbottom habitats would require the creation of artificial reef habitat at an effective mitigation ratio of 2.0 for high relief hardbottom/reef habitat and an effective mitigation ratio of 1.3 for low relief hardbottom/reef habitat (Appendix A). Mitigation reefs will be constructed in two different designs, to reflect the differences in the habitat structure of the two types of reef/hardbottom habitat to be impacted. The proposed mitigation will be type-for-type, to reflect the ecological differences between the different reef types impacted. The tables and calculations of the HEA are included in Appendix A.

Mitigation reefs will be required in two different designs, to reflect the differences in the habitat structure of the two types of hardbottom/reef habitat to be impacted. A total of 0.8

acre of low relief-low complexity reef will be required to mitigate for the new low relief reef and previously impacted hardbottom habitat (Table 3). A total of 5.4 acres of high relief-high complexity reef would be required to mitigate for the high relief impact (see Section 3.2.2 for reef design).

Table 3 Reef and Hardbottom Impacts and Proposed Artificial Reef Ratios and Areas

Habitat Type	Impact Area (ac)	Ratio	Type of Mitigation	Mitigation Required
Low Relief Reef/Hardbottom	0.6 Ac	1.3:1	Creation of LRLC	0.8 Ac
High Relief Reef/Hardbottom	2.7 Ac	2:1	Creation of HRHC	5.4 Ac
Total	3.3 Ac			6.2 Ac

4.0 PROPOSED PLAN

This mitigation plan focuses on compensation options available for unavoidable impacts associated with implementation of Alternative 2 (Recommended Plan) to seagrass and hardbottom/reef habitats located within the tidal influence of the Port Entrance Channel, including Biscayne Bay and adjacent offshore waters. Other options evaluated did not provide in-kind type-for-type replacement of habitat lost and may not be acceptable to the resource agencies unless opportunities to provide like replacement were not available or did not have a likely probability of success.

4.1 Seagrass Restoration

In order to replace local seagrass functions and values, restoration will be implemented in Biscayne Bay within areas that have been anthropogenically disturbed in the past (Fonseca et al. 1998). The preferred mitigation area is a series of interconnected submerged borrow holes located just north of Julia Tuttle Causeway (Interstate 195) where seagrass habitat has been removed in years past by dredging fill for the causeway construction. The general location of the Julia Tuttle Dredge Hole is shown on Figure 3, Proposed Seagrass Mitigation Area site. Several previously identified dredge hole sites located throughout Biscayne Bay were considered (see Table 4). The Julia Tuttle Dredge Hole was determined to be the preferred area because:

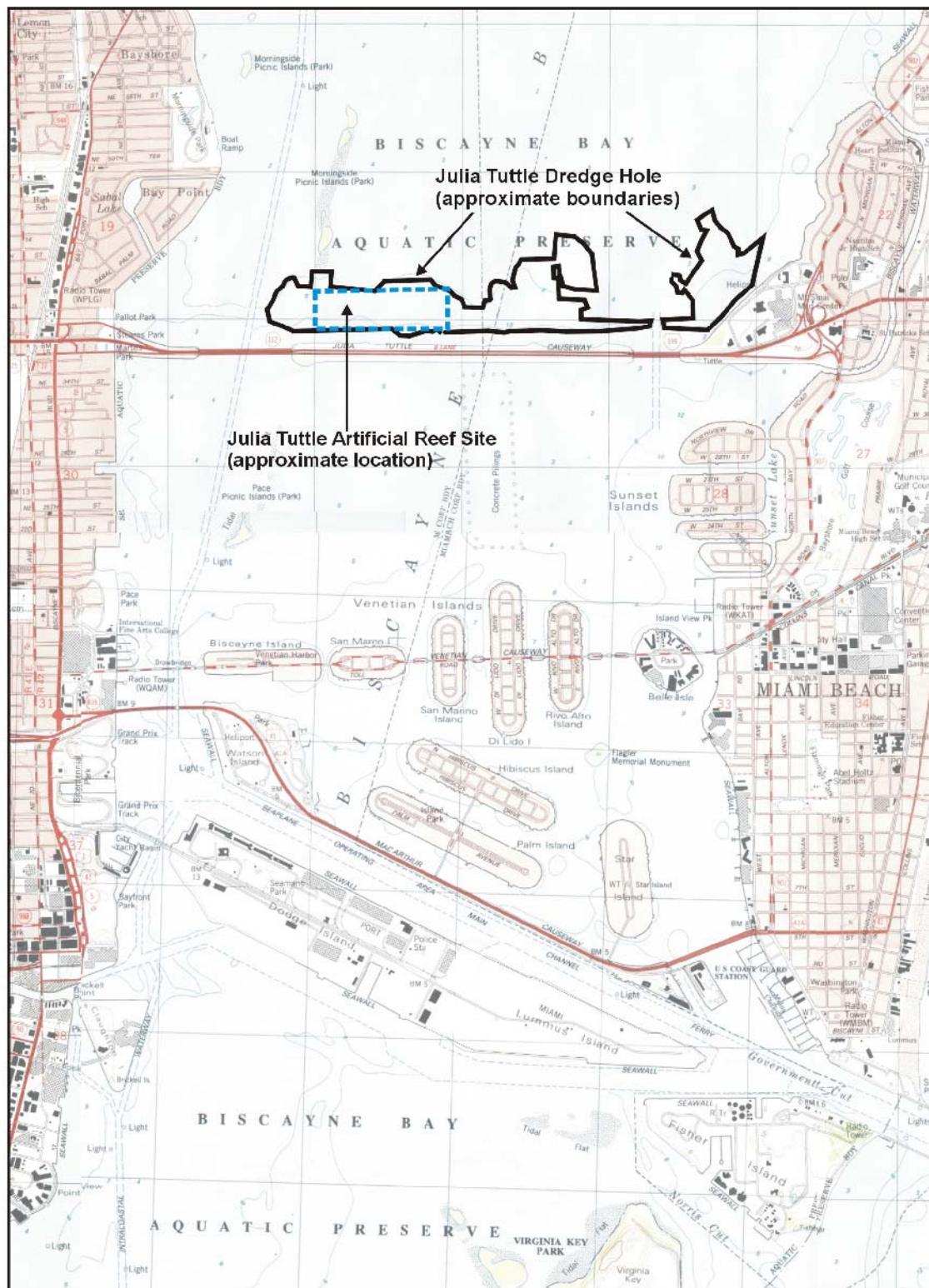
- It is almost completely surrounded by mature climax marine seagrass beds and it apparently supported seagrass habitat prior to creation of the dredge hole,
- It appears to be a good candidate for cost-effective hauling or pumping of borrow material from the Port of Miami for the purpose of topographic restoration (subject to a cost-feasibility analysis),
- It appears to experience a relatively calm but well-circulated tidal current and little or no daily perturbations from boating activities, and,
- It appears that there are sites within the hole that can be restored to seagrass over a sufficient area to achieve the desired amount of mitigation.

A reconnaissance level survey of the Julia Tuttle Dredge Hole revealed several deep areas within the larger pit feature (see Appendix L of the EIS, Marine Survey). Further detailed investigation of potential restoration sites within the pit, conducted in July 2003 and October 2003, revealed the following general conditions:

- The areas at natural grade that surround the pit were typically 5 to 8 feet deep and were generally dominated by manatee grass, *Syringodium filiforme* in sandy mud substrate. Other seagrasses, including *Thalassia testudinum*, *Halodule wrightii* and *Halophila decipiens*, occurred variably throughout the *S. filiforme*-dominated beds. Several algae, especially *Halimeda* sp. were also present. These beds had an unusual morphology in that the *S. filiforme* plants tended to have very long blades, usually one meter or more. The beds formed a very uniform and fairly dense cover with very little patchiness. The tidal current conditions were calm and older seagrass blades tended to have a heavy load of


epiphytes. The *S. filiforme*-dominated beds maintained their uniform dense cover down to a depth of about 8 feet. The beds then thinned out significantly with scattered *S. filiforme* plants occurring down to a depth of 10 or 11 feet.

- The dominant seagrass at deeper depths (10 feet to 17 feet) was *H. decipiens* with few *H. wrightii* plants occurring at the shallower end of the range. *H. decipiens* occurred as sparse patches or single runners down to about 16 to 17 feet but consistently gave way to unvegetated bottom below that depth contour.
- *Halophila johnsonii* was seen at approximate depths of 11 to 15 feet among moderately dense *H. decipiens* patches in the shallow northern reaches of the hole during the July 2003 site visit. *H. johnsonii* was not seen during the October 2003 site visit.
- The main area where at natural grade the seagrass habitat gave way to hardbottom habitat was at the western end of the hole adjacent to the Intracoastal Waterway (ICW) where stronger currents have an influence. The sandy bottom there was dominated by loggerhead sponges (*Spherospongia vesparium*), vase sponges (*Ircinia campana*), and blue sponges (species not identified), *Halimeda* algae and occasional small patches of *H. decipiens*.
- The Julia Tuttle Dredge Hole contains an artificial reef area known as the Julia Tuttle Artificial Reef Site (Figure 3). DERM, who holds the permit for the artificial reef site and is responsible for its management, considers the site to be successful and continues to add material to the site (Gary Milano, Miami-Dade County Department of Environmental Resources Management (DERM), pers. comm.). Shallow reef materials were observed at a depth of about 15 feet and had sponges, bryozoans and other organisms growing on them. Deeper reef materials tended not to support any attached growth. All of the material clearly attracted fish.
- The depths within the Julia Tuttle Dredge Hole varied throughout. It appeared that since the original dredging, some re-arrangement of sediments had occurred so that some of the hole edges remained as steep or sheer walls while other edges had sloping shelves where sediments had covered over the original excavated walls.
- The steep walls tended to contain hardbottom communities typical of submerged borrow pits. These communities were dominated primarily by loggerhead sponges and bryozoans and tended to be of relatively low diversity. The steep-walled hole edges tended to have a narrow eroded shelf of about 15 to 20 feet in width. These shelves were occupied with a mix of generally sparse sponges, algae and seagrass plants. Once the shelves sloped up to the approximate -10 elevation, the *Syringodium* plants could be seen quickly increasing in density.
- Sloping edges of the holes were variably vegetated with seagrasses, algae, scattered sponges and bryozoans, depending on the location, substrate and depth. Density and diversity tended to be lower as depth increased.
- Below a depth of about 16 to 17 feet, the bottom areas in the hole consisted of a packed mud substrate of “gelatinous” consistency and these areas were barren of vegetation. Regularly spaced holes created by bottom dwellers were scattered throughout this substrate.



Source: Port of Miami



Proposed Seagrass Mitigation Site	
Revised Mitigation Plan	
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Final Environmental Impact Statement	
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Date: January, 2004	
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	Figure 3

Based on the combined observations of the original marine survey (Appendix L) and the subsequent investigative field work, the following screening criteria were developed to assist in locating a specific seagrass restoration site within the Julia Tuttle Dredge Hole. The preferred site should:

- maximize the facilitation of natural recruitment from adjacent *S. filiforme* beds,
- avoid impacts to existing seagrass both outside and within the Julia Tuttle Dredge Hole,
- avoid the DERM permitted artificial reef area within the hole, if possible,
- have sufficient access and working area for the required equipment with no risk of damage to adjacent shallow resources.

The site that best meets the criteria is located in the approximate center of the Julia Tuttle Dredge Hole and is termed the Central Hole (Figure 4, Seagrass Mitigation Conceptual Design). This is the preferred seagrass restoration site and it has the following characteristics:

- The site varies in depth from about 12 to 13 feet down to over 30 feet.
- There are two distinct deep features that are about 22 to 30 feet in depth (see Figure 4).
- Portions of the site are bordered by steep walls while other portions are bordered by sloping topography.
- Those portions of the site at the 16 to 17 foot contour and shallower are generally vegetated with seagrasses, especially sparse *H. decipiens*.
- Those portions of the site below the 16 to 17 foot contour are unvegetated.
- Areas of natural grade adjacent to the site are dominated by *S. filiforme* with *T. testudinum*, *H. decipiens* and *H. wrightii* also being present.

4.1.1 Conceptual Seagrass Site Design

The goal of the mitigation is to compensate for the loss of climax-community seagrass habitat at the impact site by restoring a productive climax-community seagrass habitat at the mitigation site. To compensate for 7.9 acres of projected seagrass losses at the impact site, approximately 24-acres of seagrass habitat is expected to be constructed within the Proposed Seagrass Mitigation Site (the Julia Tuttle Dredge Hole, see Figure 3). Success for purposes of this conceptual mitigation design is defined as achievement of the target acreage of seagrass coverage within 5 years of site construction. The success criteria will be finalized as part of the detailed mitigation design. To achieve success, the following objectives will be implemented:

1. Fill unvegetated areas of the Central Hole with native material (dredge spoil) to restore topography for climax community seagrasses (target elevation).

2. Utilize dredge spoil material of a consistency that will allow for settling and achievement of stable slopes and for support of the maximum possible surface area of fine capping fill material.
3. Using finer capping fill material, create a stabilized surface treatment of approximately 24 acres in size (target acreage) to achieve an elevation and substrate composition suitable for recruitment of seagrasses.
4. Design the site to maximize facilitation of recruitment from adjacent seagrass beds but also incorporate strategic planting to achieve recovery within the desired timeframe.

To achieve these objectives, dredged material would either be hauled up the ICW or pumped to the mitigation site. The site boundaries will be clearly delineated in the field prior to deposition of fill. The site will be filled generally as shown in Figure 4, Illustrative Site Filling Approach. The first step will be to fill the holes to the base fill elevation. The base fill elevation is estimated to be between (-) 15 to (-) 17 feet, or the elevation below which seagrass communities no longer grow. The specific base fill elevation will be defined during detailed mitigation design, based on site surveys at one foot contours combined with biological assessments. Where the delineated site border meets a steep pit wall the fill will be leveled as closely as possible to adjacent seagrass elevation (target elevation) in order to encourage recruitment and also to improve connectivity of the restoration site to the adjacent seagrass bed community. In these specific areas, some resources may be covered by material on the narrow eroded shelf described earlier that occurs between natural grade and the sharp drop (see Figure 4). Wherever the delineated site border does not meet a steep wall the fill will be sloped up from the base fill elevation in order to avoid impacting existing seagrasses. The material will be deposited in two phases: coarse fill phase and capping phase. The coarse fill phase will utilize dredge spoil for the purpose of providing a supporting base for the site. Some amount of rocky material is acceptable for this phase provided that stable compaction and slopes are achieved. The coarse fill will be brought to within approximately one foot of the final target elevation for the site. The capping phase will utilize finer grain material suitable for seagrass recruitment and will be brought up to the target elevation. Although the site design does not specifically seek to provide seagrass or other communities on the side slopes of the mounded areas, it is likely that either seagrass and/or hardbottom communities (calcareous algae and sponges) will grow on the side slopes, based on observations in the field of similar areas with the Julia Tuttle Dredge Hole.

It is currently envisioned that the construction of the site would incorporate the following features:

- Transport: Barge access would be restricted to deep water. It appears that, should the barge transport method be used, there is more than sufficient depth and area to push the barge along the ICW, enter and exit the site, and turn the barge within the site. If a piping method is used, the pipe could be placed in deep water wherever possible. The transport method is not expected to have significant impacts on surrounding seagrass beds adjacent to the transport route or the mitigation site.
- Turbidity Control: Some method of turbidity control such as curtains would be employed at the site in order to ensure compliance with state water quality standards. Significant

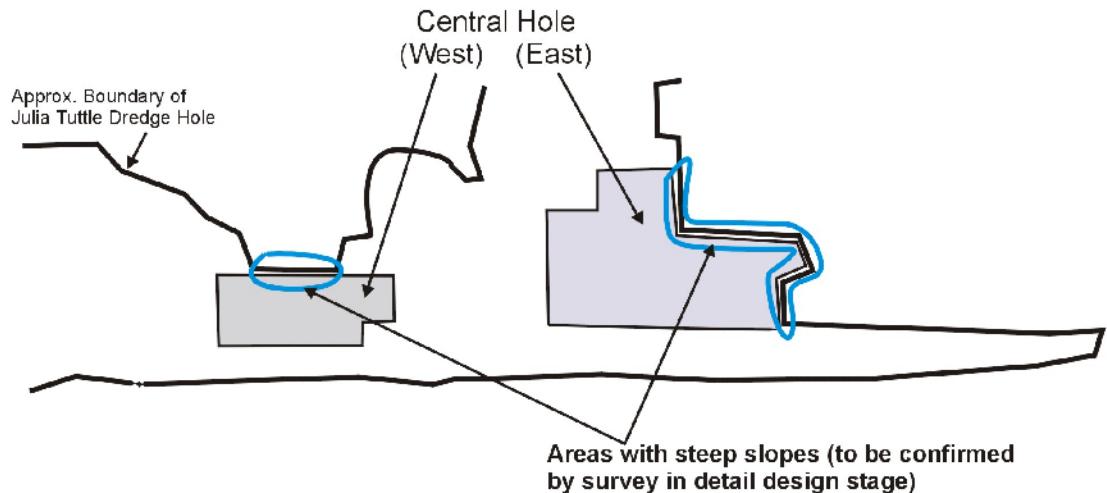
turbidity is not expected during construction since the majority of the fill will consist of coarse grain material that will drop quickly during deployment. The calm conditions that make this site a good seagrass restoration candidate will also help to contain turbidity.

- Site Grading: Regardless of the method used to transport and deploy the fill, site finishing and grading will need to achieve the target elevation as closely as possible. A flat-blade excavator will most likely be used to grade the site to the specified elevation, but a combination of methods may be used. The final method will be determined as part of the detailed mitigation design.
- Planting: Some limited seagrass planting may be employed to help ensure that success can be achieved within the desired timeframe. A final design will be developed as part of the detailed mitigation plan but it is envisioned that individual plots of *H. wrightii* and/or *S. filiforme* may be distributed over portions of the site in areas where recruitment may otherwise be slow to occur.
- Site Protection: Once the site is finished it may need to be protected from erosion, boating activities or other possible disturbance sources. The detailed mitigation design will address any protection measures such as boulder revetments or site markers that may be needed.

Once constructed, the site will be monitored. For purposes of this conceptual plan, monitoring will be designed to evaluate achievement of the following:

- recruitment of the site with seagrasses within 3 years, and
- achievement of the target acreage of seagrass coverage within 5 years.

It is anticipated that seagrass recruitment will occur rapidly by *H. wrightii* and *H. decipiens*. Other species including *S. filiforme* and *T. testudinum* are expected to colonize the site at a slower rate. Detailed success criteria, design and specifications for the seagrass mitigation will be prepared and provided for agency concurrence prior to construction. It is possible that construction techniques outlined here may change due to availability of new information during the more detailed design phase, or that a more appropriate site or sites for mitigation may be identified in the future.



PLAN VIEW

Mean Sea Level

Target Seagrass Elevation

(-) 5 to (-) 7 feet
to be confirmed
during detail design stage

Base Fill Elevation

(-) 15 to (-) 17 feet
(estimated limit of
seagrass growth,
to be confirmed during
detailed design stage)

*In gently sloping areas
fill to base elevation
to protect
existing seagrass*

(Sand cap)

Mound
(coarse material)


Base Fill

*In areas with steep
slope fill up to target
elevation and meet
natural grade in order
to maximize recruitment
and connectivity;
some existing resources in
these narrow areas may be
covered*

SECTION VIEW

Source: Port of Miami



Seagrass Mitigation Conceptual Design	
Revised Mitigation Plan	
Miami Harbor General Reevaluation Report	
Final Environmental Impact Statement	
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	Figure 4

4.2 Artificial Reef Creation

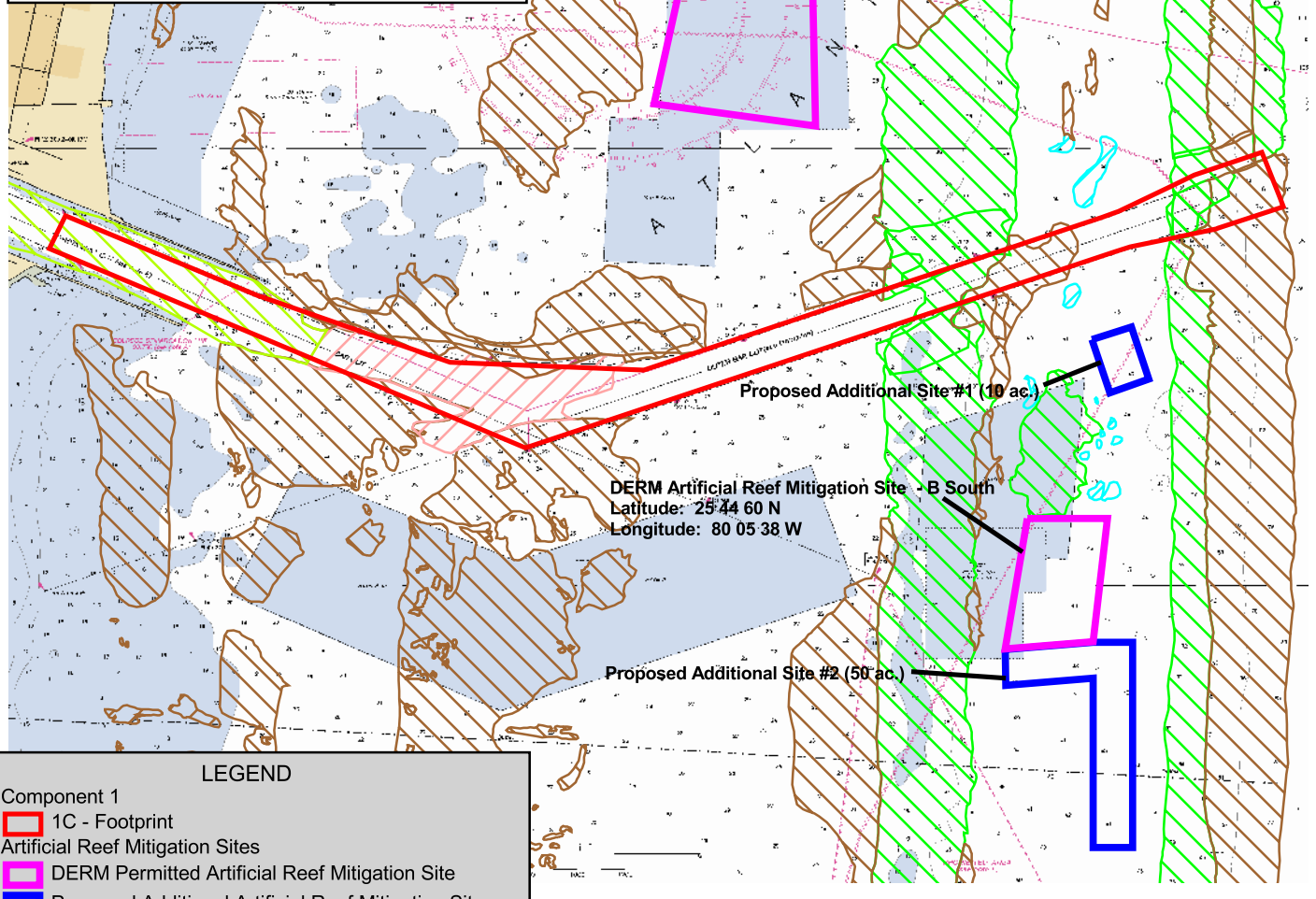
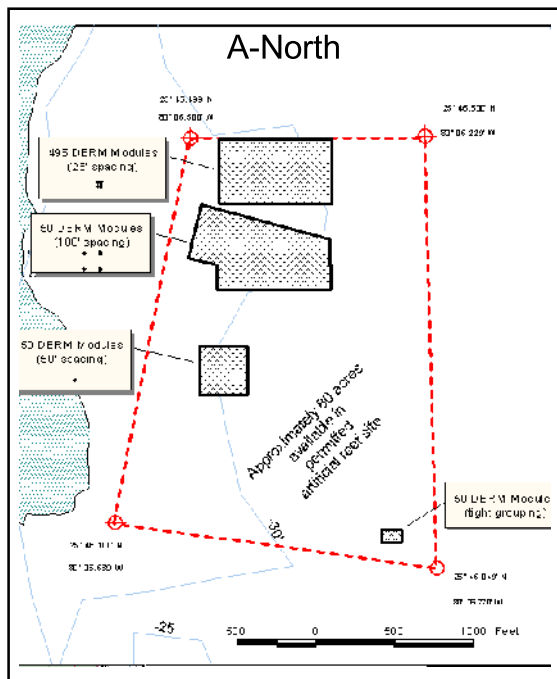
The proposed mitigation for reef and hardbottom impacts will be type-for-type, to reflect the ecological differences between the different reef types impacted. A total of 0.8 acre of low relief-low complexity (LRLC) reef will be created to mitigate for the new low relief reef and previously impacted hardbottom habitat. A total of 5.4 acres of high relief-high complexity (HRHC) reef will be created to mitigate for the high relief impact. The proposed location for mitigation reefs is found in Figure 5 and design drawings for LRLC and HRHC types are found in Figure 6. Specific design requirements and the reef design are described in this section.

4.2.1 General Design Requirements

Artificial reefs are often proposed for mitigating impacts to natural hardbottom habitats as a result of beach restoration (Lutz 1998). Mitigation reefs differ in several ways from traditional artificial reefs for fishing enhancement. Traditional artificial reefs are usually constructed offshore, are generally of high relief, are promoted as fishing destinations, and often utilize vessels or other non-natural substrate to offer divers an interesting alternative to natural reefs. In contrast, mitigation reefs should be designed to mimic the lost habitat as closely as possible in terms of relief and structural complexity. They should be placed in the same habitat depth zones as the impacted natural hardbottom/reef, and consumptive use of the reefs should be discouraged.

Artificial reefs have been used successfully for many years to mitigate impacts in sheltered waters (Duffy 1985; Davis 1985) or in relatively deep water offshore (Mostkoff 1993). Reef deployments in shallow, open coastal areas present special challenges in the wave stability of materials and burial by sand movements in this very dynamic habitat. Palm Beach County has had considerable success with deploying shallow water artificial reefs as mitigation measures. The proposed design reflects the limitations on design and placement imposed by navigation regulations, liability issues, construction limitations, and stability concerns.

Mitigation reefs have often been required to be built in the immediate vicinity of the natural reefs impacted by construction activities. In areas where the habitat that was impacted was the only habitat in the area, this approach has merit. A guiding principle of artificial reef development has always been that reefs should not be deployed adjacent to productive reef habitats. From a fisheries standpoint, reefs placed in non-reef habitats are biologically more productive as they are trophically coupled with foraging habitats that are unexploited by other reef fishes (Bortone 1998). More importantly, the shifting of reef materials in storms may severely damage adjacent natural habitats. For this reason, the Florida Artificial Reef Development Plan prohibits material from being placed within 100 yards of “live bottom” areas (Myatt and Myatt 1992). Following Hurricanes Andrew, Opal, and Erin, it was found



LEGEND

Component 1

1C - Footprint

Artificial Reef Mitigation Sites

DERM Permitted Artificial Reef Mitigation Site

Proposed Additional Artificial Reef Mitigation Site

Hardbottom / Reef Map

scat. rubble/lb

scat. rock/al/lb/sponge

patchy low relief

low relief

patchy high relief

high relief



2500 0 2500 5000 Feet

Location of Offshore Artificial Reef Sites

Revised Mitigation Plan Miami Harbor General Reevaluation Report Final Environmental Impact Statement

Scale: 1" = 2,500'

Drawn By: MR

Date: January, 2004

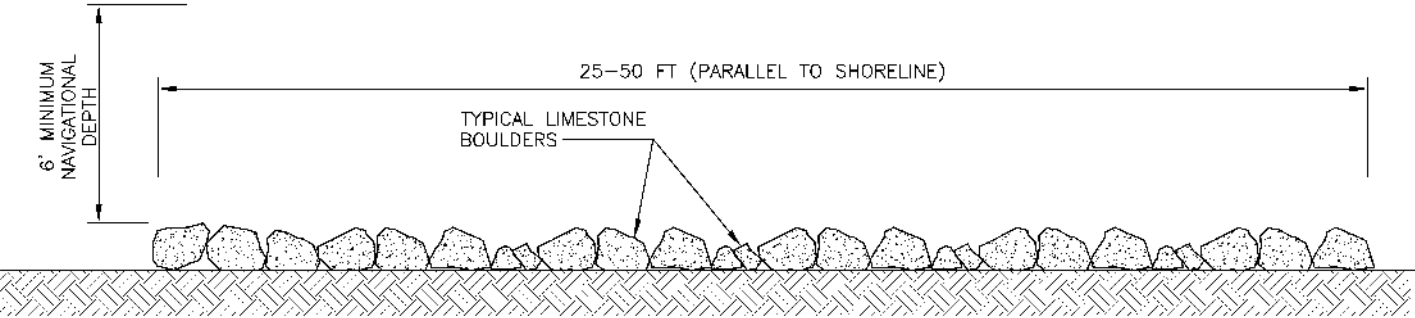


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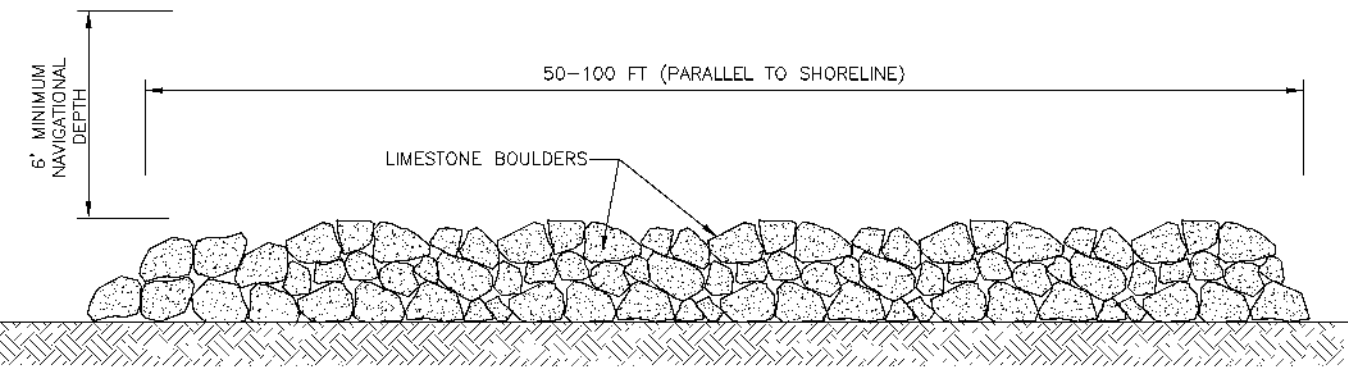
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Figure 5

Low-Relief, Low Complexity Artificial Reef Design



High-Relief, High Complexity Artificial Reef Design



Artificial Reef Design for Low and High Relief Reef	
Revised Mitigation Plan	
Miami Harbor General Reevaluation Report	
Final Environmental Impact Statement	
Scale: NTS	Drawn By: MR
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	Figure 6

that even massive materials in relatively deep water were moved or broken up by tremendous wave forces (Lin 1998, Turpin 1998). For the above reasons, sites selected for mitigation reef construction should have no significant areas of natural reef within 100 yards and no reefs should be placed directly seaward of any significant area of natural reef.

The most desirable areas for deployment of reefs are areas that have a thin veneer of sand over bedrock, which limits the extent that deployed materials will settle. After reviewing the Miami-Dade county permitted sites, it was determined that one of the sites (DERM reef site A – north of the entrance channel) is too shallow to mimic the reef that is being impacted. DERM reef site B – located to the south of the entrance channel has very little available space for reef construction. However, it already has some artificial reef located within the boundaries, which would allow for quicker colonization of artificial reef material, as well as allowing for easier monitoring since it is adjacent to a county mitigation site that is currently monitored. Water depths of this site are similar to the depths of high relief reefs being impacted by the proposed project (40 to 45 feet). The County has already completed the permitting process with the State of Florida for this artificial reef site.

The Corps reviewed two additional sites for placement of reef mitigation material. Both sites are located south of the entrance channel. The northernmost site is located north of DERM reef site B, and has shallower water depths (35 to 40 feet). The southern “L”-shaped site is directly adjacent to the DERM reef site B. However, it was determined that some hardbottom communities are located within the proposed site, which would need to be avoided (with an appropriate buffer) in using this site for mitigation

In summary – the Corps proposes to use Corps site #1 adjacent to DERM reef site B and Corps site #2. DERM reef site B does not have capacity for the entire mitigation need, DERM reef site A is too shallow for the proposed mitigation.

4.2.2 Reef Design

Two types of mitigation reefs will be constructed; HRHC reefs and LRLC reefs. The HRHC reefs are intended to mitigate for impacts to high relief habitat and the LRLC reefs are intended to mitigate for impacts to lower relief reef. The two reef types will be deployed in acreages proportional to direct impacts expected on each type of natural reef habitat in the final project design.

Limestone rock excavated from the Entrance Channel will be used in reef construction. The material will be deployed to mimic the orientation of typical natural reefs. This reef design will have a vertical relief of 3 to 5 feet and rocks will be deployed to provide the maximum structural complexity and to provide refugia for cryptic and reclusive species. As interstitial sand patches associated with reef habitat are thought to be important in the ecological function of the reef habitat, the reef footprint will contain approximately 20 percent open sand surface. Temporary buoys delineating the deployment strip will mark areas for deployment. Corner buoys for the sites shall be placed using Differential Global Positioning System

(DGPS) with sub-meter accuracy. Natural limestone provides an ideal substrate for the establishment of a fouling community and colonization by the common reef community species. HRHC reefs are intended to provide persistent habitat with higher complexity and habitat diversity than LRLC hardbottom or reefs.

LRLC reefs will have a vertical relief of 1 to 2 feet and will be placed inshore of, and shallower than, HRHC reefs. It is recognized that the LRLC reefs may be periodically buried by shifting sands, like the low relief natural reefs they are intended to mimic. This does limit their habitat value to some extent, but it has been suggested (albeit without much empirical evidence) that this sort of ephemeral, low relief habitat may be particularly important in supporting the recruitment and post settlement survival of juvenile fishes. Dredged limestone rock will be placed in sites where they may be expected to partially settle in the substrate and should provide LRLC habitat. To provide interstitial sand habitat, approximately 20 percent of the LRLC reef footprint shall be open sand. Deployment sites will be delineated as outlined above for HRHC reefs.

Construction of mitigation reefs will take place during dredging of the Entrance Channel, such that suitable rock material excavated from the channel may be used for reef building.

4.2.3 Reef Monitoring

The monitoring program for the mitigation reefs will consist of both physical and biological components. An initial pre-construction monitoring event will be performed to provide baseline conditions for future comparison. Physical monitoring will assess the degree of settling of the reef materials after the first year, and biological monitoring will assess populations of algae, invertebrates, and fishes, as compared with concurrent control sampling of natural reefs for five years. Monitoring will be conducted annually in the summer months. In order to provide a permanent record of reef conditions and biota, each sampling effort will include video transects covering representative areas of the mitigation reefs.

Fish population evaluations will be based on visual censuses conducted separately on HRHC and LRLC mitigation reefs and high and low relief control reefs. The point-count method (Bohnsack and Bannerot 1986) will be used for fish assessment. This method has the advantage of gathering quantitative data in a relatively short time in a very repeatable pattern that is relatively insensitive to differences in habitat structure. Each census will have a duration of 5 minutes and a radius (the distance from the stationary observer) of 10 feet. Ten censuses will be collected on each of the four reef types. Data from these types of censuses are rarely distributed, so the Wilcoxon Rank-Sum or a similar nonparametric test will be used for significance testing. The criteria for mitigation reef success will be a finding of no significant difference at $p=0.05$ between reef type pairs (HRHC vs. high relief control and LRLC vs. low relief control).

Results of all mitigation reef-monitoring efforts will be summarized in an annual report to be completed by December 31 of each year the monitoring program is in place. Copies of the report will be distributed to all agencies and interested parties.

5.0 EFFECTIVENESS OF PROPOSED MITIGATION

A review of the effectiveness of each proposed mitigation treatment is summarized below.

5.1 Seagrass Restoration

Restoring seagrass beds, if successful, can be an appropriate mitigation strategy due to its high ecological value and declining abundance. Seagrass restoration adds habitat value to unvegetated sand or mud substrates. The addition of seagrass beds increases the productivity and diversity of the unvegetated bottom, which can directly compensate for the historic loss in productivity and diversity.

Fonseca, et al. (1996a, 1996b) found that within three years, restored seagrass beds (*H. wrightii*) planted on 0.5-m centers reach the same areal density and support animal densities, number of taxa, and species composition equivalent to natural beds. Some restored seagrass beds support invertebrate populations that are as or more abundant than those in natural grassbeds (Bell, et al. 1993). Restored seagrass beds appear to be as suitable as natural seagrass beds for juvenile and small adult fish (Brown-Peterson, et al. 1993).

Restored seagrass beds support animal densities similar to natural seagrass beds when shoot density is only one-third that of a natural seagrass bed (Fonseca et al. 1996). Thus, the habitat value of a restored seagrass bed is maximized relatively quickly, prior to the restored bed reaching the same vegetative density as a natural seagrass bed. In addition to providing habitat itself, seagrass beds increase the productivity of adjacent habitats. Irandi and Crawford (1997) found that the presence of seagrass beds adjacent to tidal marshes increased the abundance and growth rates of fish in the tidal marsh.

Research has identified that seagrass beds are more diverse and productive than unvegetated substrate. Average fish densities in natural seagrass beds were ten times greater than those on unvegetated areas (~20 individuals/m² versus 1.74 individuals/m²). Shrimp densities in natural shoal grass beds averaged 151 individuals/m² compared to 3.02 individuals/m² in unvegetated areas. Crab densities in natural seagrass beds were 20 to 50 individuals/m² compared to an average of 1.91 individuals/m² on unvegetated areas (Fonseca et al. 1996). Within 1.5 years of planting, restored seagrass beds support shrimp, fish, and crab densities similar to natural seagrass beds (Fonseca et al. 1996). Thus, restored seagrass beds can increase the density of shrimp, fish, and crabs by 10 to 50 times compared to unvegetated substrates.

Although research has identified that seagrass beds are more diverse and productive than unvegetated substrates, relatively few studies compare secondary productivity between seagrass beds and other habitats. Heck, et al. (1995) determined that eelgrass beds in the northeastern United States had macroinvertebrate production 5 to 15 times higher than adjacent unvegetated habitats. At least a similar increase in productivity is expected for *H. wrightii* and *T. testudium*, which have a higher primary productivity than eelgrass. Also, a

similar increase in abundance, diversity, and productivity of fish species may also be expected.

Restoration of seagrass communities, while still considered experimental and not highly successful by resource agencies, can enhance habitat heterogeneity and the diversity of invertebrate and fish communities, if carefully implemented. The recent treatise on seagrass restoration entitled "Guidelines for the Conservation and Restoration of Seagrasses in the United States and Adjacent Waters" by Fonseca, et al. (1998) discusses the benefits and risks associated with seagrass restoration. Given the documented success of more recent efforts to restore seagrass communities, including those in South Florida, restoration is quickly becoming a proven resource management tool in some areas where conditions are appropriate.

Restoration of a three-acre borrow area in North Biscayne Bay was completed in the late 1990's by Miami-Dade Department of Environmental Resources Management (DERM) and recently inspected by NMFS, FWS, and DERM staff during an agency site visit with the USACE's contractor in March of 2002. Although no monitoring has been done by DERM since planting of the site, a visual inspection by the agency team revealed that seagrass occurs throughout the site and was dominated by *H. wrightii* and *T. testudinum*. Discussions with DERM staff indicate the old borrow area was filled with rubble and sand and planting units of both *H. wrightii* and *T. testudinum* installed. Based on this evidence of general success, all in attendance agreed that seagrass restoration was a viable option for mitigating seagrass loss.

Another example of successful seagrass restoration is the Miami-Dade sewage cross-bay force main installed by the Miami-Dade Water and Sewer Authority Department in the mid-1990s. The project required trenching of over one mile of Miami Harbor baybottom for pipeline installation, including excavation of 1.80 acres of seagrass beds. Once the pipeline was installed the 22-foot wide trench path was refilled and allowed to recruit with seagrasses. Recruitment had begun within one-year and after two years seagrasses and macroalgae covered the trench pathway so that it was no longer visible on aerial photography.

Recent success has also been achieved with restoration of propeller scars through various methods in the Florida Keys. Filling of scars, planting with seagrass and "spiking" scars with concentrated nutrient loads have all been used to encourage expansion and recruitment of seagrasses there (Kenworthy et al. 2000).

5.2 Artificial Reef Construction

Currently there are many options for the construction of artificial reefs. Methods used previously have included limestone boulders, concrete tetrahedrons, and Reef BallsTM, among others. Miami-Dade County currently prefers the use of limestone boulders as the material for artificial reef construction. Placement of limestone material in any or all of these areas would provide suitable habitat replacement for the loss of reef associated with channel widening and deepening.

6.0 REFERENCES

- Bell, S.S., L.A.J. Clements, and J. Kurdziel. 1993. Production in Natural and Restored Seagrasses: A Case Study of a Macrobenthic Polychaete. *Ecological Monographs* 3(4): 610-621.
- Bohnsack, J.A. 1979. Photographic quantitative sampling studies of hard-bottom benthic communities. *Bulletin of Marine Science*. 29:242-252.
- Bohnsack, J.A. and S.P. Bannerot. 1986. A stationary visual census technique for quantitatively assessing community structure of coral reef fishes. US Dept. of Commerce, NOAA Technical Report NMFS 41:1-15.
- Bortone, S.A. 1998. The impact of artificial reef fish assemblages on their potential Forage area: lessons in artificial reef study design. Pages 82-85 in: William Horn, ed. Florida Artificial Reef Summit '98. Florida Department of Environmental Protection. Tallahassee, FL.
- Brown-Peterson, N.J., M.S. Peterson, D.A. Rydene, and R.W. Eames. 1993. Fish Assemblages in Natural versus Well-Established Recolonized Seagrass Meadows. *Estuaries* 16(2): 177-189.
- Coastal Technology Corporation. 1989. Filling Program for Dredged Depressions in North Biscay Bay. Engineering report prepared for Metropolitan Dade County.
- Davis, G.E. 1985. Artificial structures to mitigate construction impacts to spiny lobster, *Panulirus argus*. *Bulletin of Marine Science* 37(1) 151-156.
- Duffy, J.M. 1985. Artificial reefs as mitigation. A small scale case history. *Bulletin of Marine Science* 37(1) 397.
- Fonseca, M.S., D.L. Meyer, and M.O. Hall. 1996b. Development of planted seagrass beds in Tampa Bay, Florida, U.S.A: II. Faunal components. *Mar. Ecol. Prog. Ser.* 132:141-156.
- Fonseca, M.S., J.W. Kenworthy, and G.W. Thayer. 1998. Guidelines for the Conservation and Restoration of Seagrasses in the United States and Adjacent Waters. NOAA Coastal Ocean Program Decision Analysis Series, No. 12. NOAA Coastal Ocean Office, Silver Spring, MD.

- Fonseca, M.S., W.J. Kenworthy, and F.X. Courtney. 1996a. Development of planted seagrass beds in Tampa Bay, Florida, U.S.A.:I. Plant components. *Mar. Ecol. Prog. Ser.* 132: 127-139.
- Heck, K.L., K.W. Able, C.T. Roman, and M.P. Fahay. 1995. Composition, Abundance, Biomass, and Production of Macrofauna in a New England Estuary: Comparisons Among Eelgrass Meadows and other Nursery Habitats. *Estuaries* 18(2):379-389.
- Irlandi, E.A., and M.K. Crawford. 1997. Habitat Linkages: the effects of intertidal saltmarshes and adjacent subtidal habitat on abundance, movement and growth of an estuarine fish. *Oecologia* 110:222-230.
- Kenworthy, W.J., M.W. Fonseca, P.E. Whitfield, K. Hammerstrom, and A.C. Schwarzschild. 2000. A comparison of two methods for enhancing the recovery of seagrasses into propeller scars: mechanical injection of a nutrient and growth hormone solution vs. defecation by roosting seabirds. NOAA Coastal Ocean Program Decision Analysis Series No. 12. NOAA Coastal Ocean Office, Silver Spring, MD. 40 pp.
- Lin, P.C.-P. 1998. Stability analysis of artificial reefs. Pages 94-103 in: William Horn, ed. Florida Artificial Reef Summit '98. Florida Department of Environmental Protection. Tallahassee, FL.
- Lutz, R.V. 1998. The use of artificial reefs as mitigation for impacts to nearshore hardbottom habitat caused by beach nourishment. Pages 50-51 in: William Horn, ed. Florida Artificial Reef Summit '98. Florida Department of Environmental Protection. Tallahassee, FL.
- Mostkoff, B.J. 1993. The development and application of modular artificial reefs for use in habitat mitigation as part of the Dade County artificial reef program. Pages 123-130 in: William Horn, ed. Florida Artificial Reef Summit '93. Florida Department of Environmental Protection. Tallahassee, FL.
- Myatt, E.N. and D.O. Myatt, III. 1992. Florida artificial reef development plan. Florida Department of Natural Resources. Tallahassee, Florida.
- National Oceanic and Atmospheric Administration (NOAA). 2000. Habitat Equivalency Analysis: An Overview. National Oceanic and Atmospheric Administration. Silver Spring, Maryland. 23 pp.
- Race, M.S., and M.S. Fonseca. 1996. Fixing compensatory mitigation: what will it take? *Ecological Applications*. 6:94-101.
- South Atlantic Fishery Management Council. 1998. Final Habitat Plan for the South Atlantic Region: Essential Fish Habitat Requirements for Fishery Management Plans of the South Atlantic Fishery Management Council. Charleston, SC. 408 pp.

Turpin, R.K. 1998. The effects of hurricanes and fishing on artificial reefs. Pages 86-92 In: William Horn, ed. Florida Artificial Reef Summit '98. Florida Department of Environmental Protection. Tallahassee FL.

Zar, J.H. 1984. Biostatistical Analysis. Prentice-Hall, New Jersey.

APPENDIX A
Habitat Equivalency Analyses

Table A-1: HEA effective acreage gained from recovery of low-relief hardbottoms

Assumptions: dredging leaves 10% service, w/ linear increase

<u>Year</u>	<u>% Service Level</u>	<u>% Service Loss</u>	<u>Effective Ac lost</u>	<u>Discount Factor</u>	<u>Discount Off ac lost</u>
2003	10.00%	90.00%	0.60	0.97	0.58
2004	17.50%	82.50%	0.50	0.94	0.47
2005	25.00%	75.00%	0.45	0.91	0.41
2006	32.50%	67.50%	0.41	0.88	0.36
2007	40.00%	60.00%	0.36	0.85	0.30
2008	47.50%	52.50%	0.32	0.82	0.26
2009	55.00%	45.00%	0.27	0.79	0.21
2010	62.50%	37.50%	0.23	0.76	0.17
2011	70.00%	30.00%	0.18	0.73	0.13
2012	77.50%	22.50%	0.14	0.70	0.09
2013	85.00%	15.00%	0.09	0.67	0.06
2014	92.50%	7.50%	0.05	0.64	0.03
2015	100.00%	0.00%	0.00	0.61	0.00

Total effective-acre years/ac: 3.07

Table A-2: HEA effective acreage gained from recovery of low-relief hardbottoms

Assumptions: 20% service immediate, w/ linear increase

<u>Year</u>	<u>% Service Level</u>	<u>% Service Increase</u>	<u>Discount Factor</u>	<u>Discount Eff ac gain</u>
2003	20.00%	0.00%	1.00	0.00
2004	26.67%	6.67%	0.97	0.06
2005	33.33%	13.33%	0.94	0.13
2006	40.00%	20.00%	0.91	0.18
2007	46.67%	26.67%	0.88	0.23
2008	53.33%	33.33%	0.85	0.28
2009	60.00%	40.00%	0.82	0.33
2010	66.67%	46.67%	0.79	0.37
2011	73.33%	53.33%	0.76	0.41
2012	80.00%	60.00%	0.73	0.44
2013	86.67%	66.67%	0.70	0.47
2014	93.33%	73.33%	0.67	0.49
2015	100.00%	80.00%	0.64	0.51

Total effective-acre years/ac: 3.90

Table A-3: HEA acreage calculation for low-relief hardbottom compensation

Impact area	0.6
Present discounted interim losses	3.07
Present discounted lifetime gains per acre of replacement project	3.9
R= # acres required for compensation	
3.07=3.9*R	
R=	3.07/3.9
R=	0.787179

Effective mitigation to compensation ratio: 1.316667

Table A-4: HEA effective acreage lost from impacts to high-relief reefs

Assumptions: dredging leaves 10% service, w/ linear increase

<u>Year</u>	<u>% Service Level</u>	<u>% Service Loss</u>	<u>Effective Ac lost</u>	<u>Discount Factor</u>	<u>Discount Eff ac lost</u>
2003	10.00%	90.00%	2.70	0.97	2.62
2004	13.00%	87.00%	2.35	0.94	2.21
2005	16.00%	84.00%	2.27	0.91	2.06
2006	19.00%	81.00%	2.19	0.88	1.92
2007	22.00%	78.00%	2.11	0.85	1.78
2008	25.00%	75.00%	2.03	0.82	1.65
2009	28.00%	72.00%	1.94	0.79	1.53
2010	31.00%	69.00%	1.86	0.76	1.41
2011	34.00%	66.00%	1.78	0.73	1.29
2012	37.00%	63.00%	1.70	0.70	1.19
2013	40.00%	60.00%	1.62	0.67	1.08
2014	43.00%	57.00%	1.54	0.64	0.98
2015	46.00%	54.00%	1.46	0.61	0.88
2016	49.00%	51.00%	1.38	0.58	0.79
2017	52.00%	48.00%	1.30	0.55	0.71
2018	55.00%	45.00%	1.22	0.52	0.63
2019	58.00%	42.00%	1.13	0.49	0.55
2020	61.00%	39.00%	1.05	0.46	0.48
2021	64.00%	36.00%	0.97	0.43	0.41
2022	67.00%	33.00%	0.89	0.40	0.35
2023	70.00%	30.00%	0.81	0.37	0.30
2024	73.00%	27.00%	0.73	0.34	0.25
2025	76.00%	24.00%	0.65	0.31	0.20
2026	79.00%	21.00%	0.57	0.28	0.16
2027	82.00%	18.00%	0.49	0.25	0.12
2028	85.00%	15.00%	0.40	0.22	0.09
2029	88.00%	12.00%	0.32	0.19	0.06
2030	91.00%	9.00%	0.24	0.16	0.04
2031	94.00%	6.00%	0.16	0.13	0.02
2032	97.00%	3.00%	0.08	0.10	0.01
2033	100.00%	0.00%	0.00	0.07	0.00

Total effective-acre years/ac: 25.76

Table A-5: HEA effective acreage gained from recovery of high-relief reefs

Assumptions: 20% service immediate, w/ linear increase

Year	% Service Level	% Service Increase	Discount Factor	Discount Eff ac gain
2003	20.00%	0.00%	1.00	0.00
2004	22.67%	2.67%	0.97	0.03
2005	25.33%	5.33%	0.94	0.05
2006	28.00%	8.00%	0.91	0.07
2007	30.67%	10.67%	0.88	0.09
2008	33.33%	13.33%	0.85	0.11
2009	36.00%	16.00%	0.82	0.13
2010	38.67%	18.67%	0.79	0.15
2011	41.33%	21.33%	0.76	0.16
2012	44.00%	24.00%	0.73	0.18
2013	46.67%	26.67%	0.70	0.19
2014	49.33%	29.33%	0.67	0.20
2015	52.00%	32.00%	0.64	0.20
2016	54.67%	34.67%	0.61	0.21
2017	57.33%	37.33%	0.58	0.22
2018	60.00%	40.00%	0.55	0.22
2019	62.67%	42.67%	0.52	0.22
2020	65.33%	45.33%	0.49	0.22
2021	68.00%	48.00%	0.46	0.22
2022	70.67%	50.67%	0.43	0.22
2023	73.33%	53.33%	0.40	0.21
2024	76.00%	56.00%	0.37	0.21
2025	78.67%	58.67%	0.34	0.20
2026	81.33%	61.33%	0.31	0.19
2027	84.00%	64.00%	0.28	0.18
2028	86.67%	66.67%	0.25	0.17
2029	89.33%	69.33%	0.22	0.15
2030	92.00%	72.00%	0.19	0.14
2031	94.67%	74.67%	0.16	0.12
2032	97.33%	77.33%	0.13	0.10
2033	100.00%	80.00%	0.10	0.08

Total effective-acre years/ac: 4.84

Table A-6: HEA acreage calculation for high-relief compensation

Injured area	2.7
Present discounted interim losses	25.76
Present discounted lifetime gains per acre of replacement project	4.84
R= # acres required for compensation	
25.76=4.84*R	
R= 25.76/4.84	
R= 5.322314	

Effective mitigation to compensation ratio: 1.971227